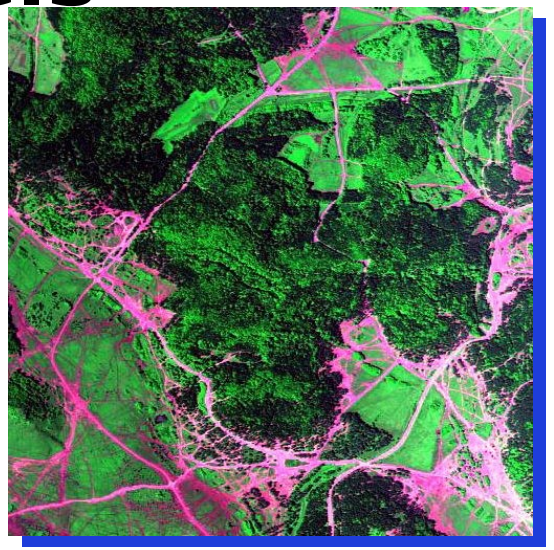
Classification of Hyperspectral Reflectance Data for the Examination of Soils and Cover Types at CMTC Hohenfels



- Albert Boehm, US Army 282 BSB - CMTC Hohenfels, Germany
- Jerry Johnston PhD, Pangaea Information Technologies Ltd., Chicago, USA
- Horst Klemm, IABG mbH, Germany

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CMTC Hohenfels
Bavaria /Germany

Area 16,000 ha / 160 km²

90% undeveloped land

Large forest areas

Jurassic limestone / karst
Surface water is scarce

Provides habitat for large number of floral & faunal

US Army / Environmental Management Office (EMO)

- **Protection of forests, range lands, fish, wildlife, and other natural resources**
- **Keep a functional ecosystem and endangered species withing training area**

US Army / Environmental Management Office (EMO)

- Intensive environmental monitoring
- Data acquisition (topography, vegetation, soil, ...)

plus

- Water & erosion control programs
- Land Condition Monitoring programs

to provide

- a basis for decisions concerning
  - training intensity
  - land rehabilitation requirements

Remote Sensing Data

- **First Generation**

- **Multispectral satellite data for erosion, landcover mapping, habitat modeling, ...**
- **Aerial photography for production of DEM´s for training damages assessment, orthoimagery, ...**
- **...**

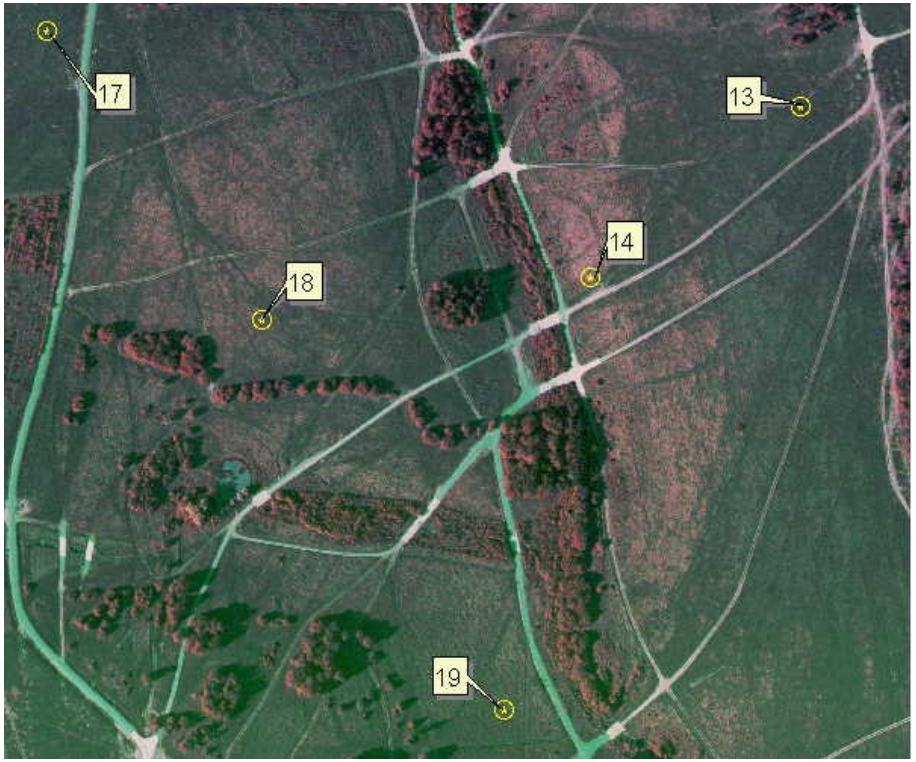
- **Second Generation**

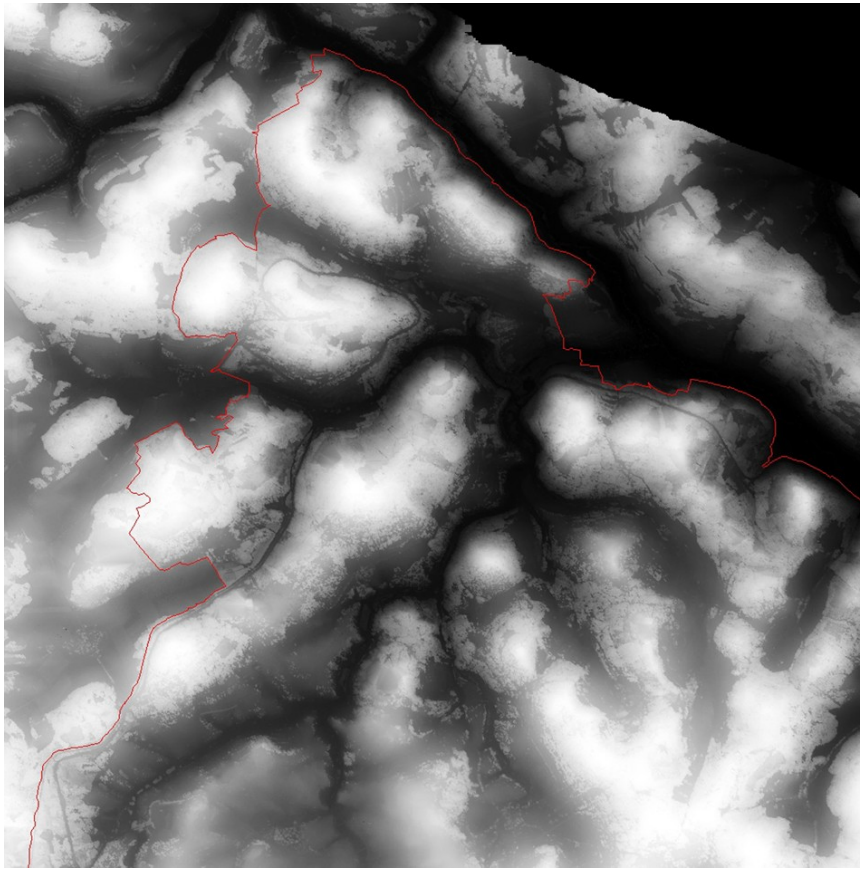
- **Multi- and hyperspectral airborne data for vegetation mapping, erosion modelling, ...**
- **High-Resolution digital photography and elevation data to support numerous activities**
- **...**

Remote Sensing Systems Used

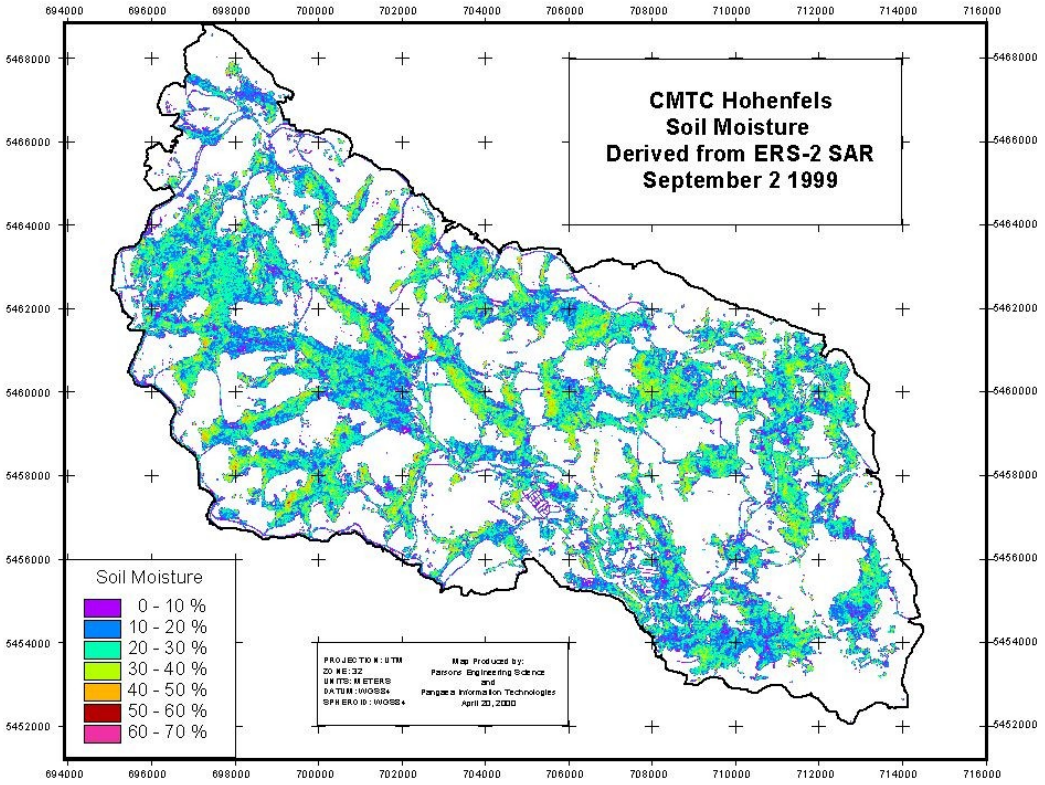
- **Spaceborne**
  - **Landsat**
  - **SPOT**
  - **IRS**
  - **ERS-2 SAR**
  - **IKONOS**
- **Airborne**
  - **Aerial Photography**
  - **Daedalus AADS 1268**
  - **HRSC-A**
  - **HyMap**
  - **LIDAR**

Aerial Photography / Digital Elevation Models

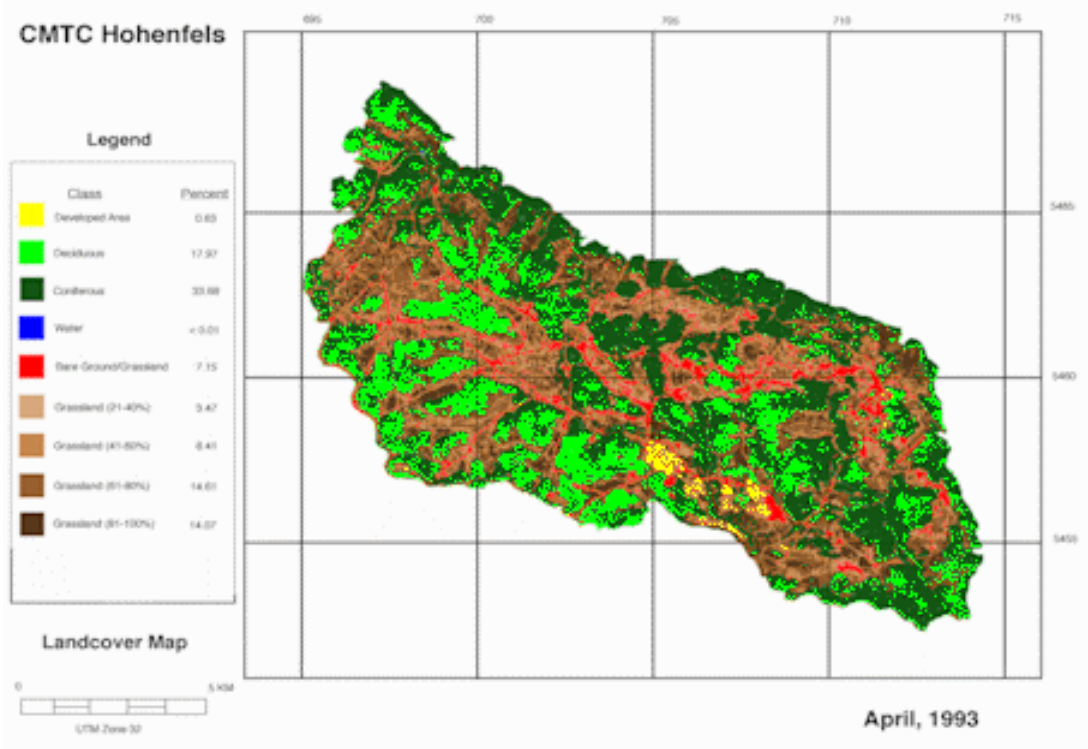




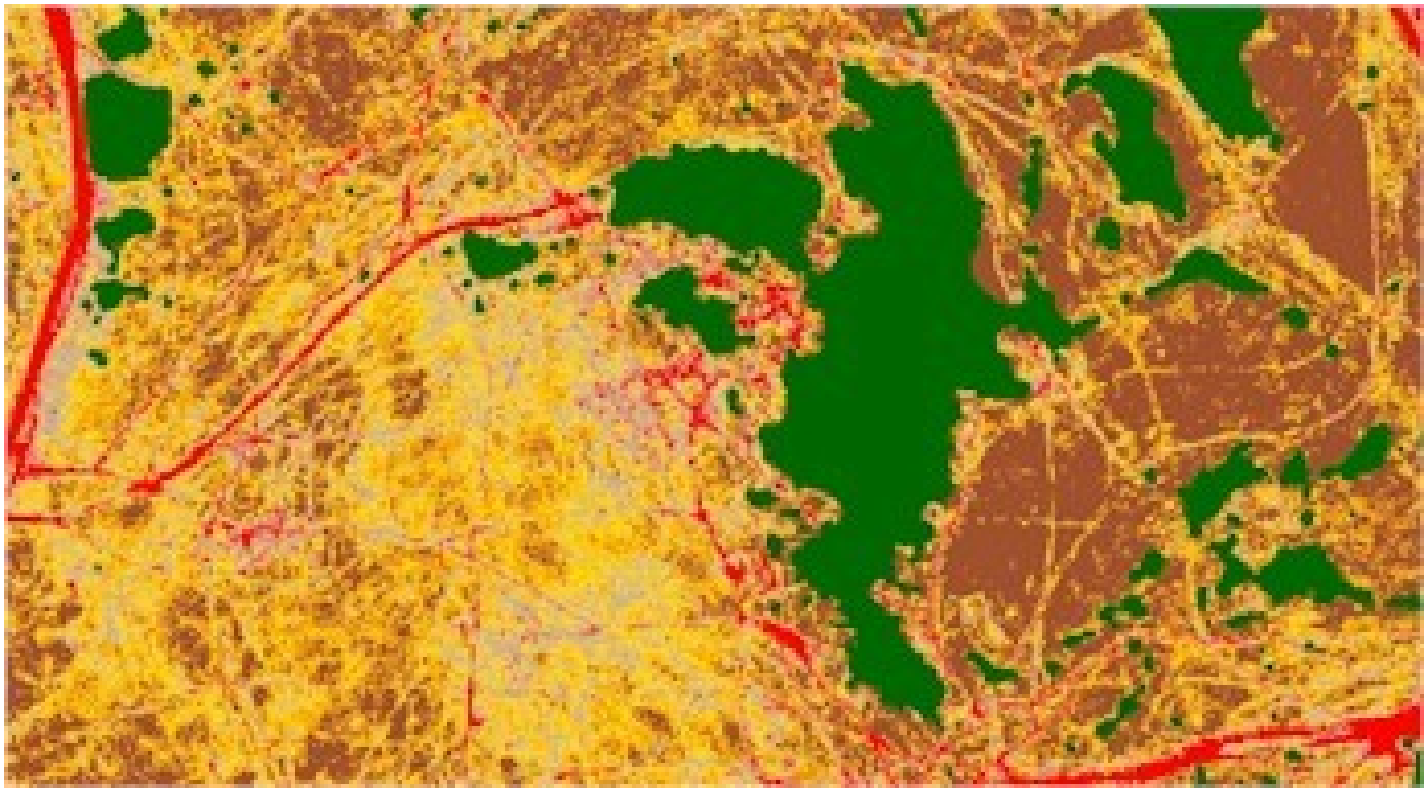
Application using ERS-2 Data



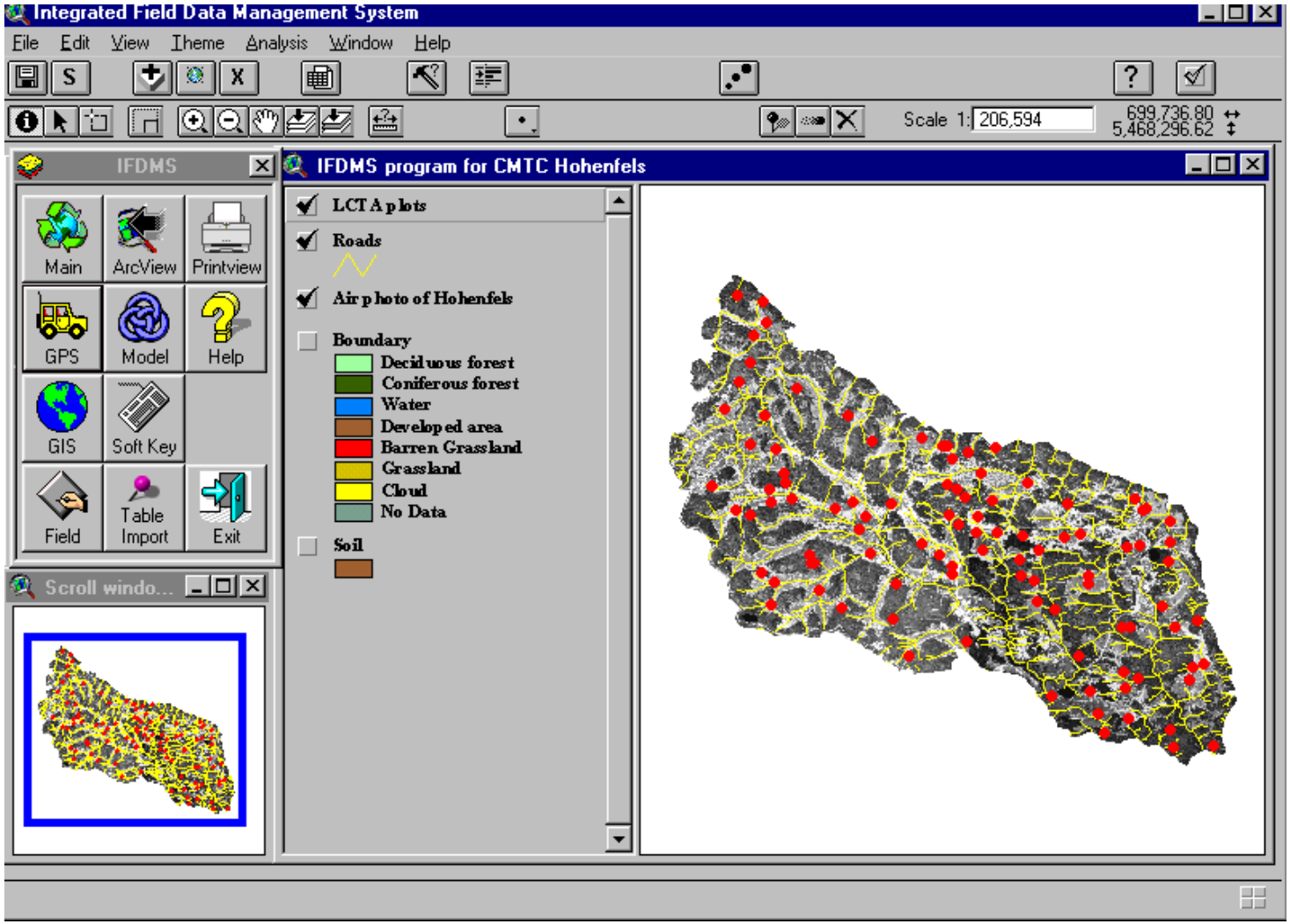
Landcover mapping



Hi-Res Landcover Mapping



The Integrated Field Data Management System (IFDMS)

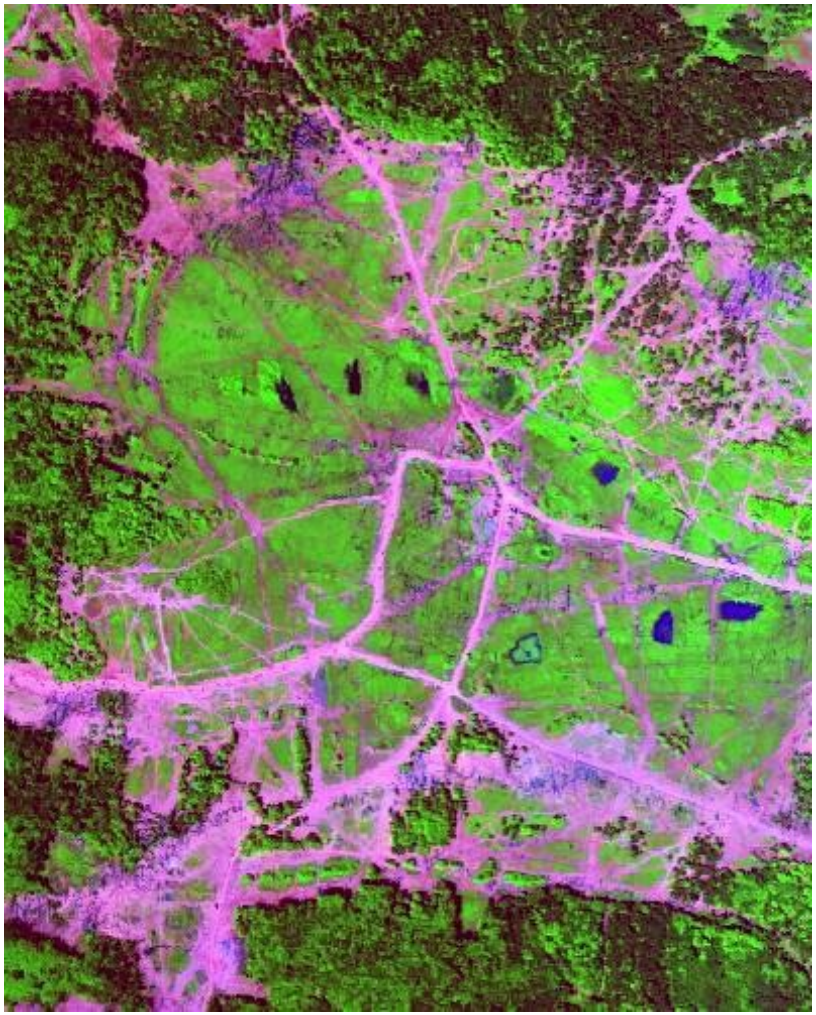


Hyperspectral reflectance data

<u>The goal of a recent project</u>:

- **Investigate the extent to which hyperspectral data can be used as indicator to evaluate soil related maneuver damages**

Study area and HyMap data



HyMap (RGB 116-26-5)

(1) Study area (20 km² out of 200 km²)
CMTC Hohenfels/Germany

(2) HyMap data

Spec.	Wav. range [nm]	No. of bands	Bandwidth [nm]
VIS	400- 900	32	15
NIR	885-1350	32	16
SWIR I	1400-1800	32	16
SWIR II	1900-2500	32	20

(3) Data take
recorded on 18.July 1999

time	12:00 – 14:30 (UTC)
flight heading	180° (south to north)
altitude	2715 m (asl)
pixel size	4.4 m

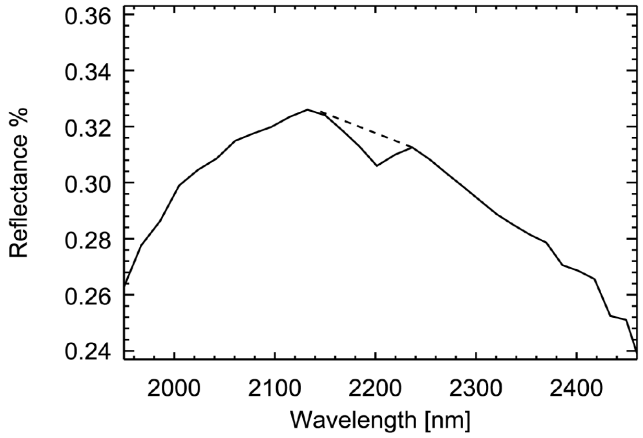
(4) Preprocessing
- on board radiometric and spectral calibration
- geometric correction
- atmospheric correction (empirical line)

Analysis of HyMap data

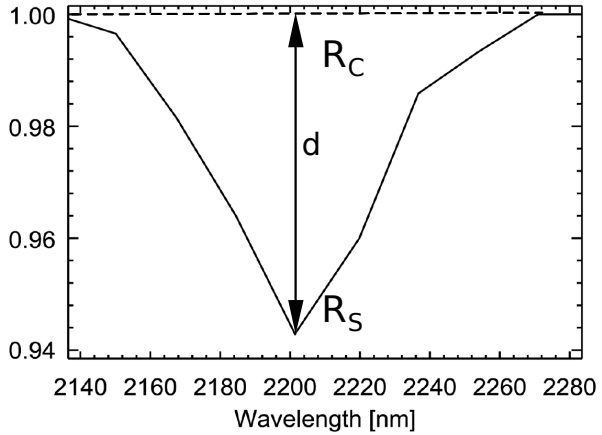
The potential of the HyMap data was analyzed with regard to

- Quantification of mineral contents of soil (clay, carbonate, iron)
- Differentiation of surface cover types

Clay mineral absorption



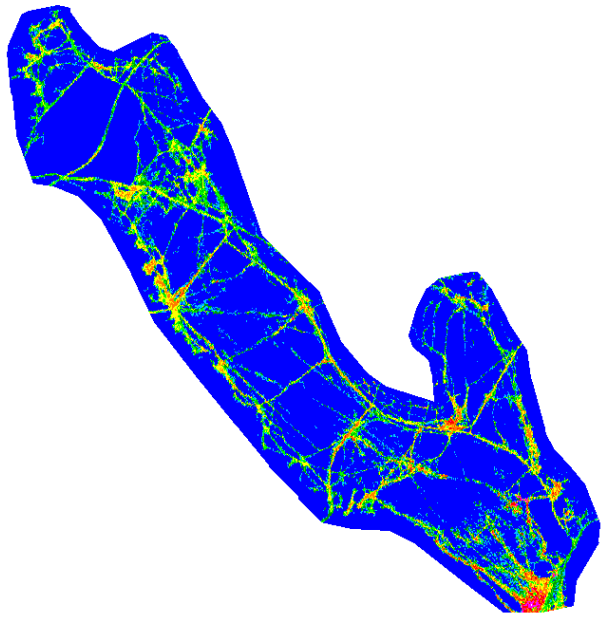
Clay absorption feature spanned by hull function

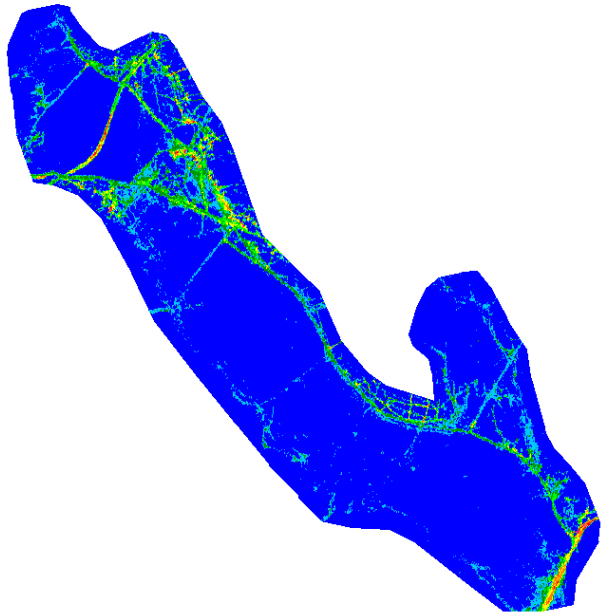


Depiction of absorption depth (d) of clay feature

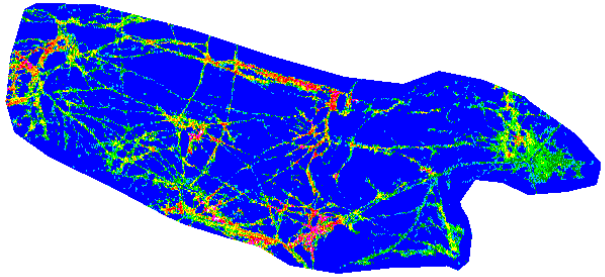
$$d = 1 - \frac{R_s}{R_c}$$

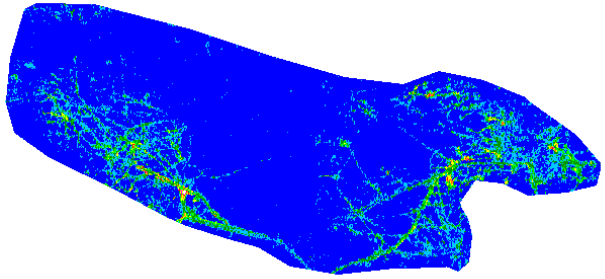
Clay and Carbonate Absorption





Testsite 1





Testsite 2

Legend:

- 0 - 12.5 %
- 12.5 - 25 %
- 25 - 37.5 %
- 37.5 - 50 %
- 50 - 62.5 %
- 62.5 - 75 %
- 75 - 87.5 %
- 87.5 - 100 %
- Extrema

0 450 m

Clay

Carbonate

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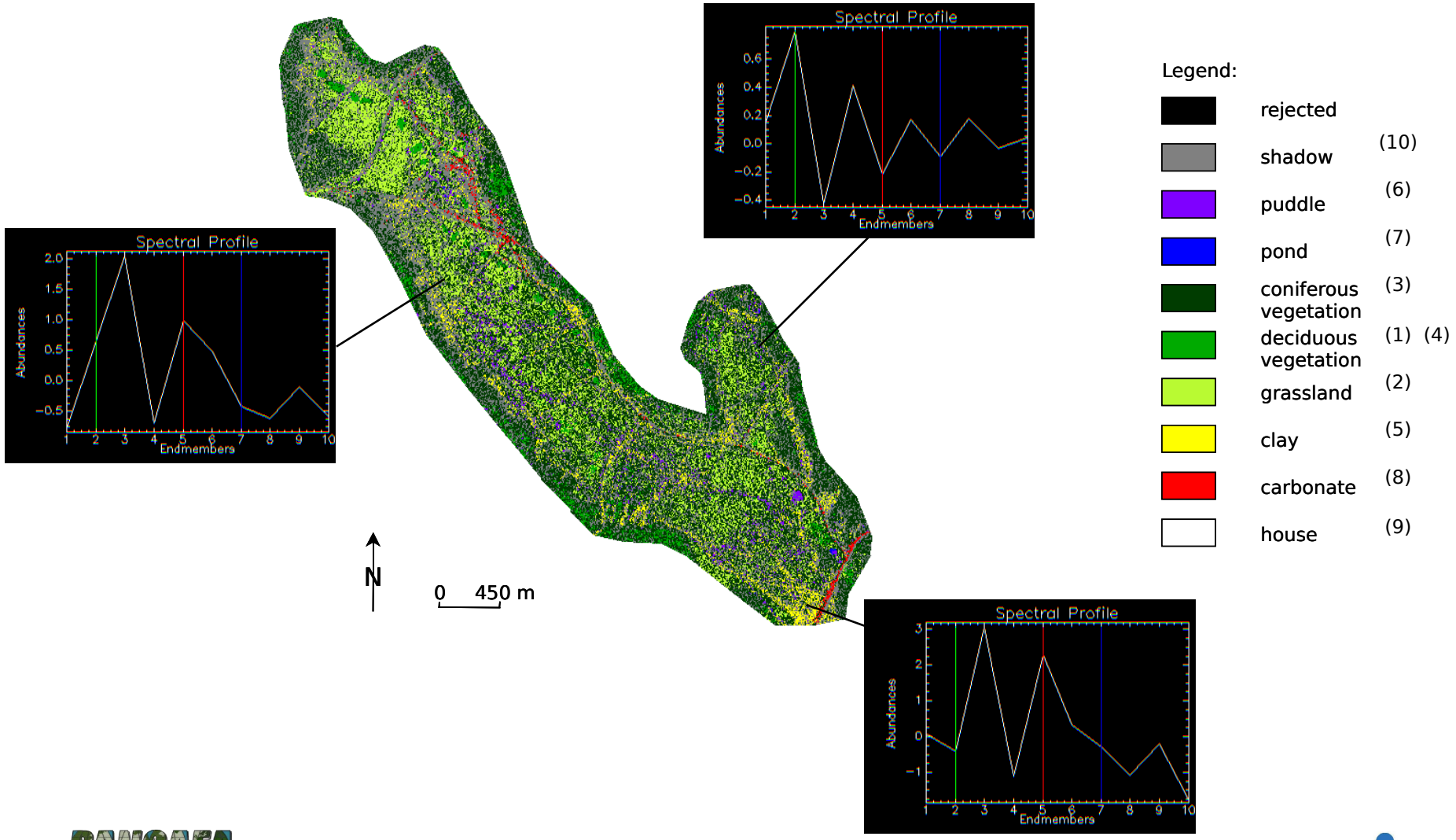
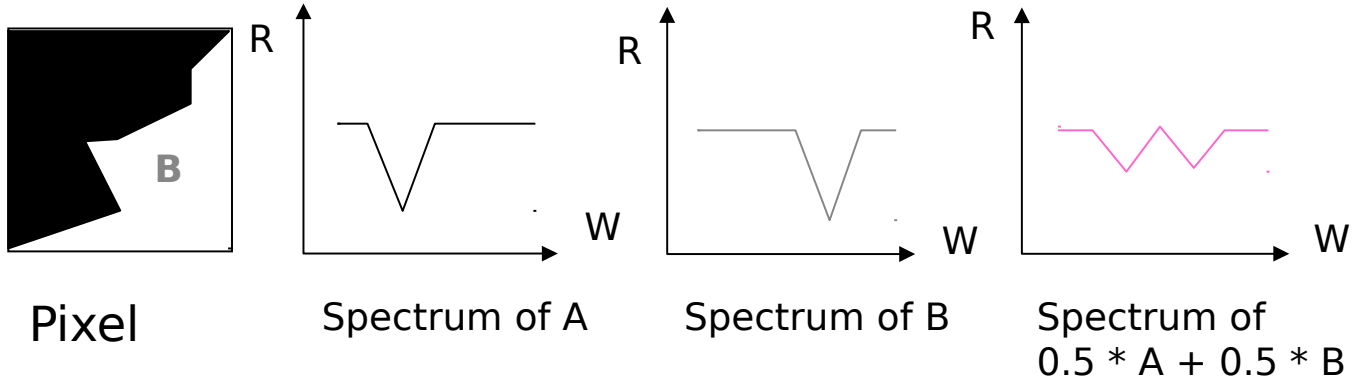
Linear spectral unmixing – dominating surface cover type



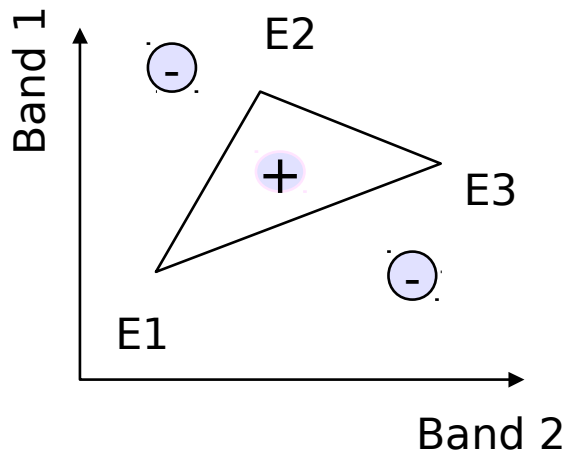
Basic idea of linear spectral unmixing



Linear spectral mixture models allow estimation of the abundance of each end-member (EM) within a pixel. Since these techniques are not suitable for an area-wide analysis of (urban) surfaces representing a large number of spectrally similar EMs, the mathematical models were extended and a new method for pixel-oriented EM selection was developed. This method reduces the number of possible EM combinations for each pixel by introducing spectrally pure seedlings and a list of predefined EM combinations into a neighborhood-oriented iterative unmixing procedure.

EM requirements

- Spectral characteristics of EMs have to be significantly different
- EMs habe to be positive abundances for the majority of the image pixels



List concept

- Reduce the number of possible EMs within a pixel
- Exclude combinations which do not make sense

List of EM combinations

Index	EMs
1	asphalt – tree
2	asphalt – meadow
3	asphalt – bare ground
4	water – bare ground
...	...

Pixel-oriented selection of endmember combinations and iterative unmixing

List of EM-combinations

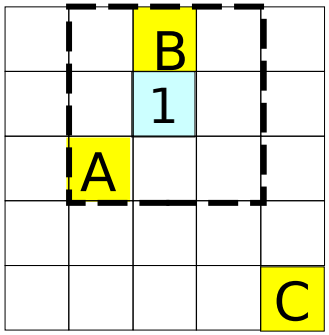
A – B

A – C

B - C

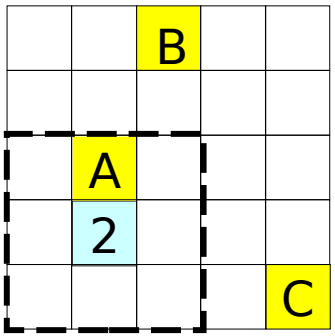
Selected EM-combinations

Case 1



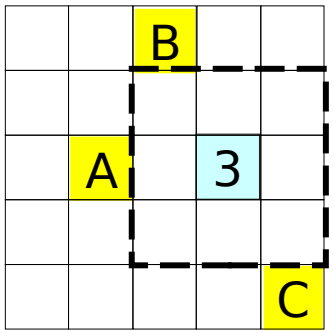
A - B

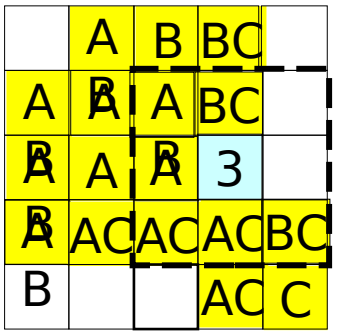
Case 2



A – B
A – C

Case 3





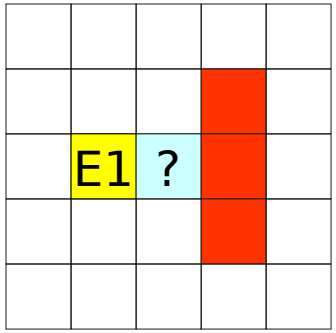
A – B
A – C
B – C

1. Iteration

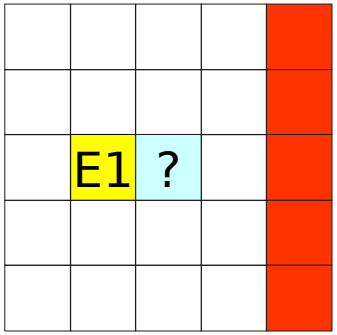
2. Iteration

Spatial constellations for selection of endmember combinations

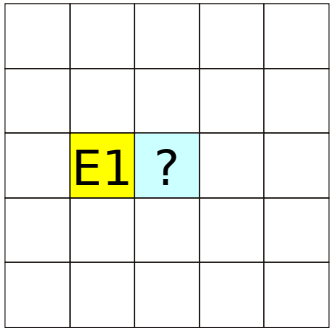
1. Priority

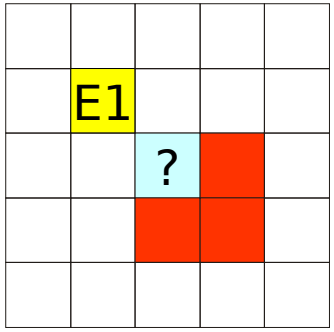


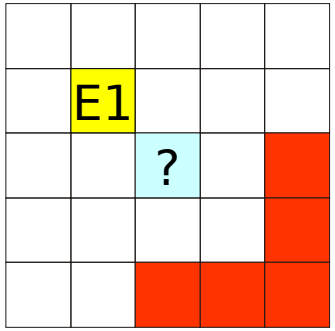
2. Priority

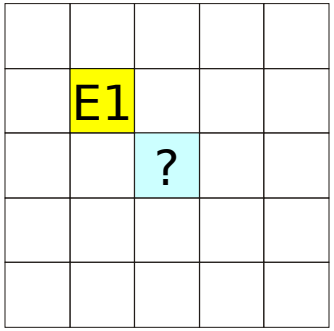


3. Priority







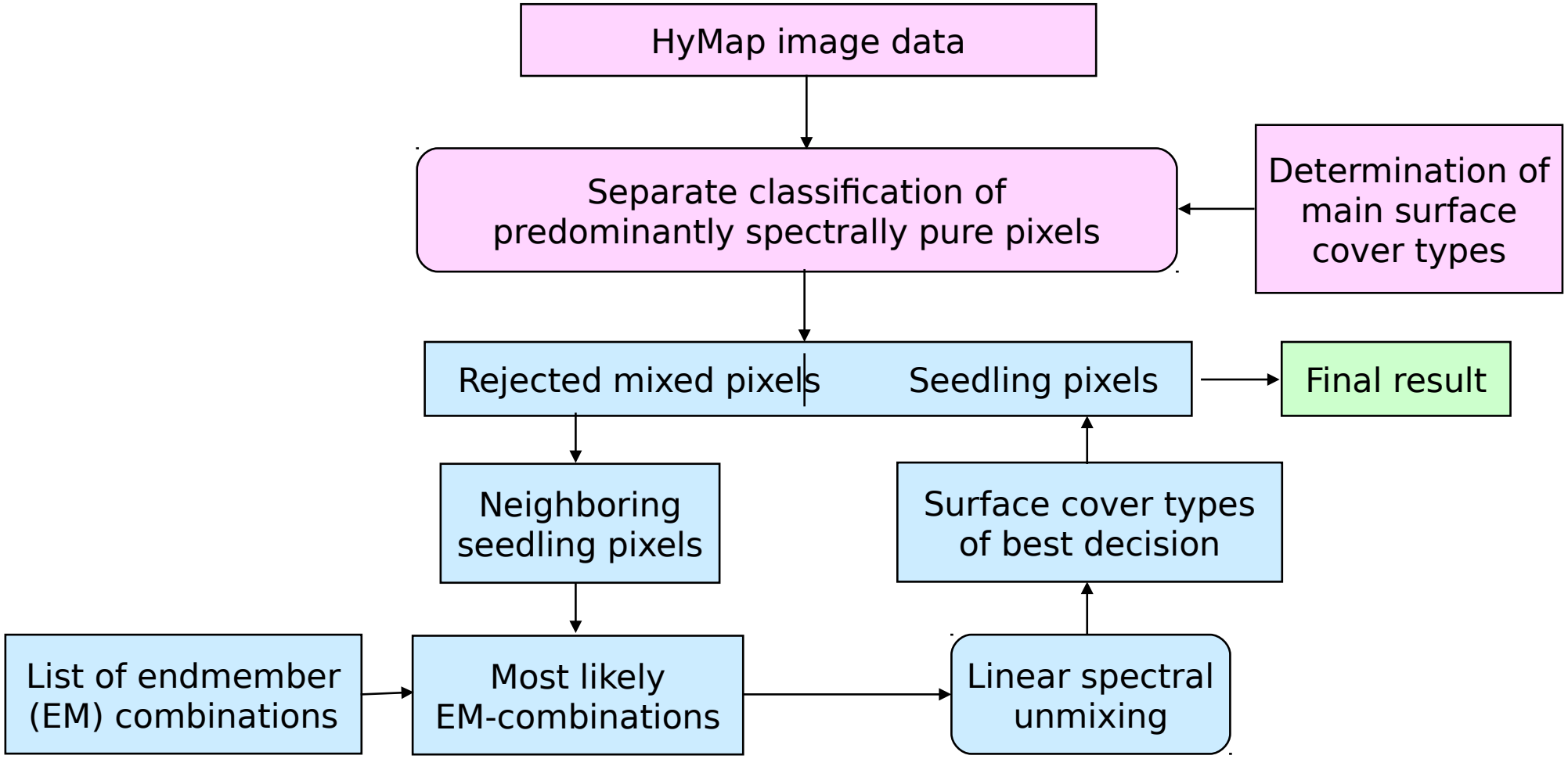


? Mixed pixel

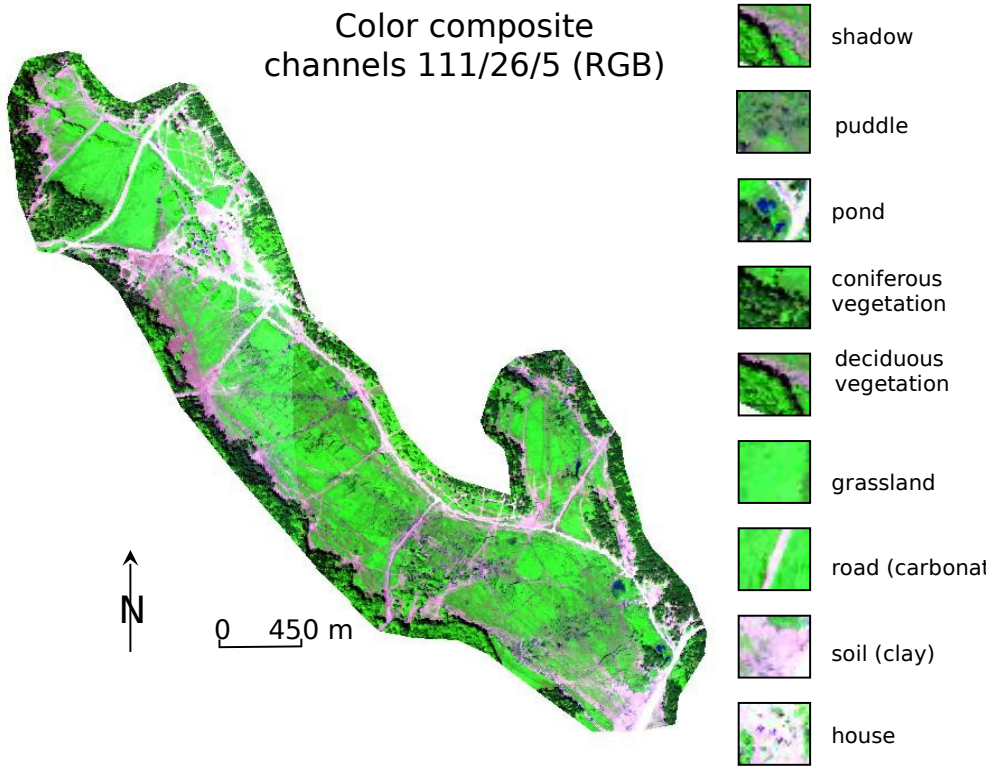
E1 First EM

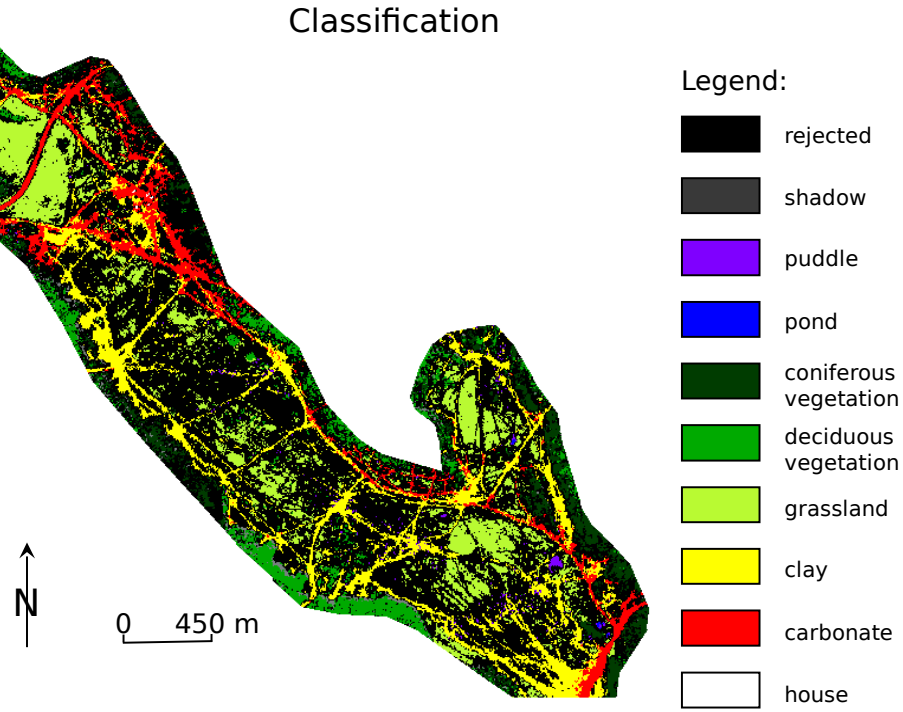
Position of possible second EM

Flowchart of combined classification and unmixing procedure

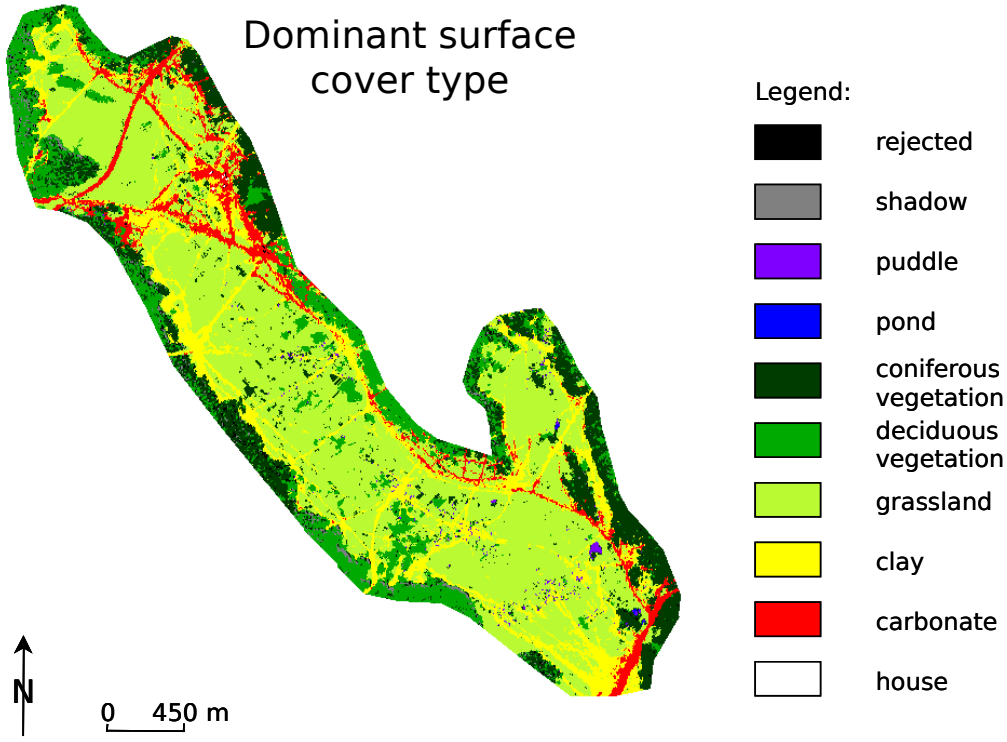


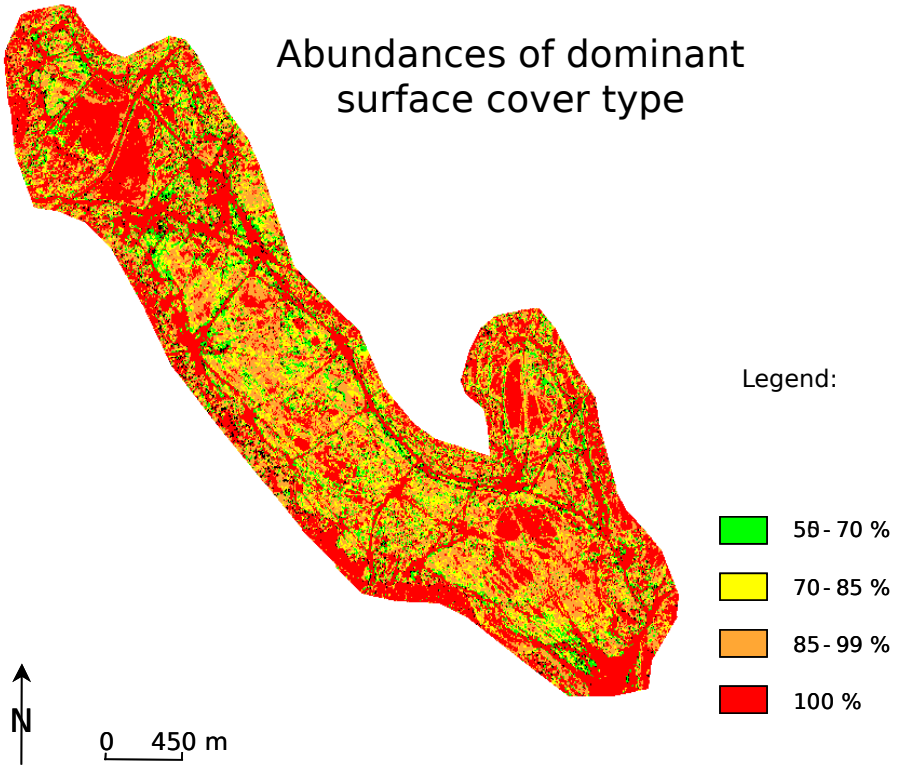
Color composite and classification of predominantly spectrally pure surface cover types





Dominant surface covertype and abundances





Conclusion

↗ **With hyperspectral data a differentiation and quantification of soil and surface cover types is possible for the areas such as the CMTC Hohenfels**

↗ **A soil characterization as indicator for endangered areas can be achieved**

↗ **New additional soil and vegetation related parameters for further studies and modeling (e.g. soil erodibilty, soil compaction) were obtained**

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